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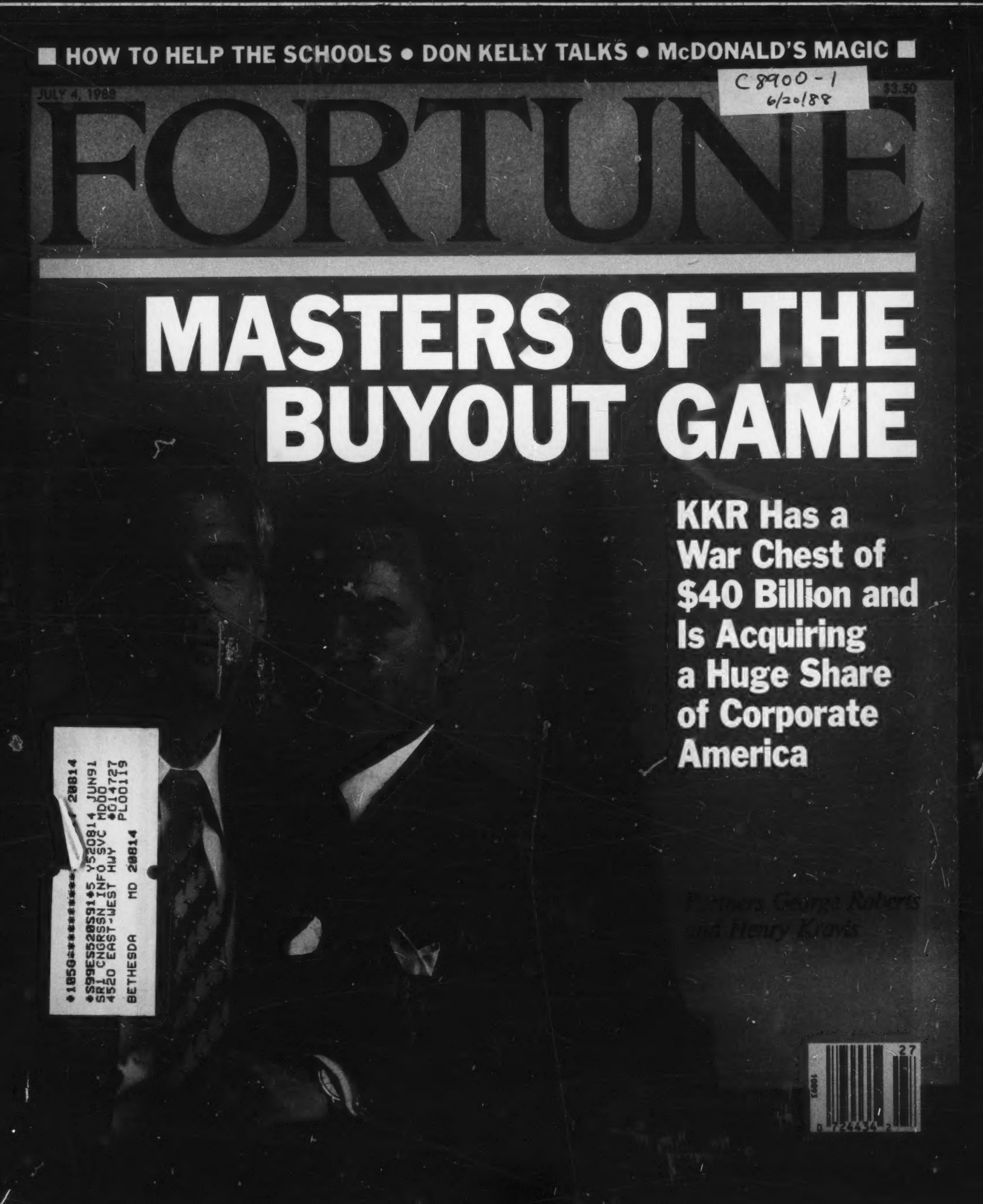
FORTUNE

MASTERS OF THE BUYOUT GAME

KKR Has a War Chest of $40 Billion and Is Acquiring a Huge Share of Corporate America

Partners George Roberts and Henry Kravis



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JULY 4, 1988

FORTUNE

"These are Type A people. The fact that they've made a lot of money doesn't matter. Each deal is a new challenge." PAGE 52

COVER: George Roberts (left) and Henry Kravis were photographed in San Francisco by David Strick—Onyx.

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EDITOR'S DESK

SINCE ITS FOUNDING in 1930, FORTUNE has been known for—among many other attributes—its distinguished design. It is full of lavish pictures and graphics that entice the eye, excite the mind, and convey the sweep and drama of global business. Design was recently cited as a major element in our National Magazine Award for general excellence. We are happy now to introduce a new design, one that we believe combines the best elements of the past and the future.

The new logo reaches back to FORTUNE's roots, with an elegant lettering that evokes the memory of our first issue. Pictured below are the logos of that issue, as well as our most recent issue and this issue. For our stories we introduce a typeface, Times Roman, that is bigger and more readable than the old print. And we will be able to say a bit more in our headlines with our new Franklin Gothic type. The Contents has been expanded from one page to two, and carries a summary of each story. We also have moved Fortune Forecast and Personal Investing to the front of the magazine.

JOHN ABBOTT

Art director Margery Peters

NINA BARNETT

Frances Fifield and David Sloan

The design is essentially the work of art director Margery Peters, who collaborated closely with the editors. A veteran of *New York*, *Esquire*, and other magazines and a sometime composer of pop music, Peters joined FORTUNE in 1982 to help develop the previous revision in format. "The last logo responded to the values of high technology," she says. "Now people are looking to re-explore traditional values."

Fortune
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FORTUNE

Logos: First, last, new

Assisting Peters was designer Frances Fifield, who constructed dozens of mock-ups for each section of the magazine until they found the combination of typeface and layout that worked best. Fifield and deputy technology chief David Sloan translated the design into the complex language of modern computers, so that an editor can load stories into the production system at the push of a button. Peters and her colleagues follow in the great tradition of magazine design. "When I look through the best magazines from the 1940s," she says, "there is a definite little voice speaking to me that has a lot to do not only with how the magazine is written but also with how it is presented." We hope you agree that FORTUNE's stories now live in an even more hospitable setting, and that our pictures, illustrations, and charts speak to you with an authoritative, pleasant voice.

Marshall Loeb

MANAGING EDITOR

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A WARMING WORLD:

Rising global temperatures could disrupt wheat farmers, electric utilities, and military strategy. Which companies win or lose depends on how well they plan ahead. ■ *by Anthony Ramirez*

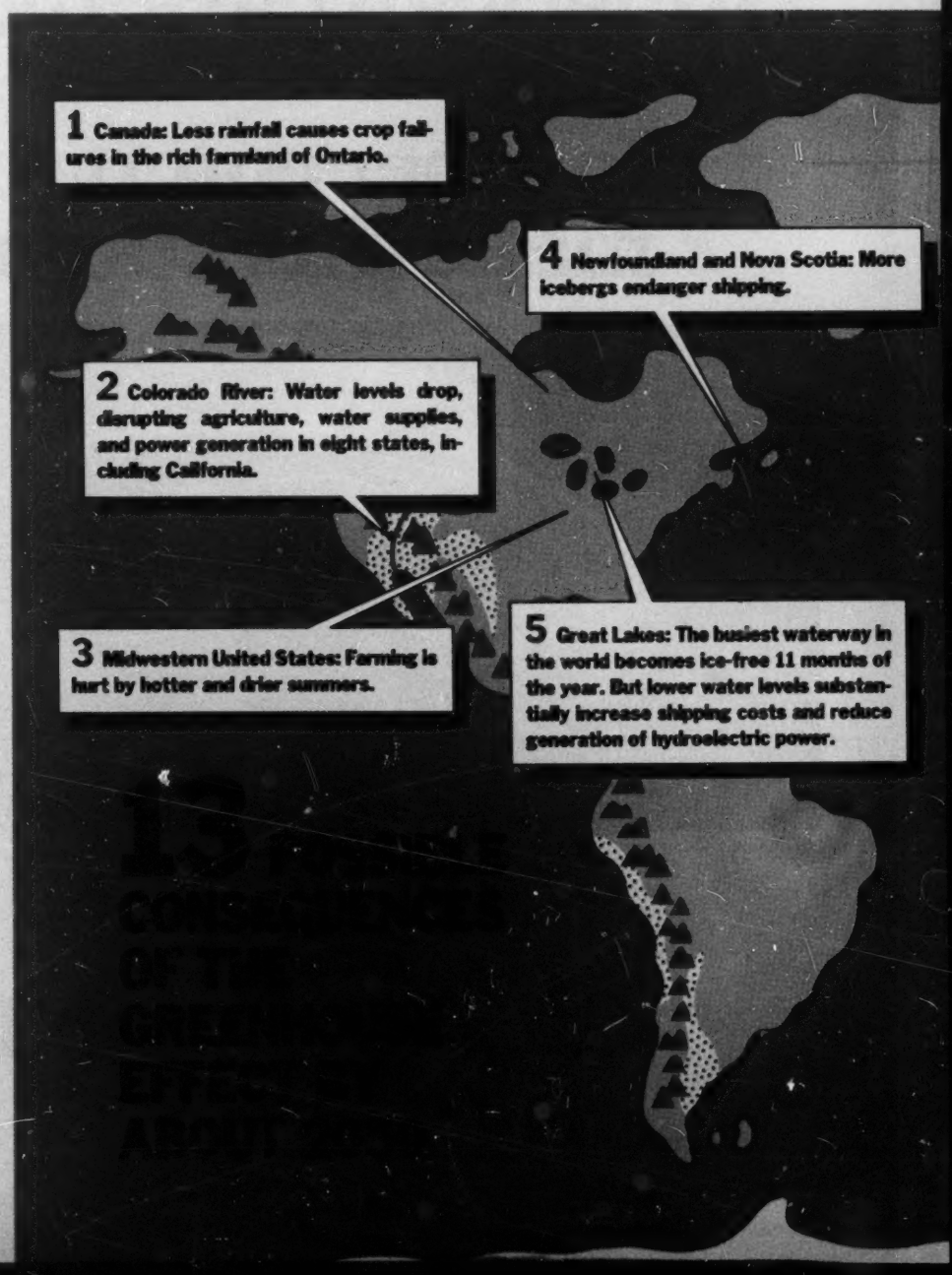
A PHYSICAL CHILL settled on the 14th century at its very start, initiating the miseries to come. The Baltic Sea froze over twice, in 1303 and 1306-7; years followed of unseasonable cold, storms, and rains, and a rise in the level of the Caspian Sea. Contemporaries could not know it was the onset of what has since been recognized as the Little Ice Age . . . lasting until about 1700. Nor were they yet aware that, owing to the climatic change, communication with Greenland was gradually being lost, that the Norse settlements there were being extinguished, that cultivation of grain was disappearing from Iceland and being severely reduced in Scandinavia.

– Barbara Tuchman, A Distant Mirror

Like the 14th century, the 21st century is in for nasty weather—but of the opposite kind. Although the earth has undergone periods of warming and cooling in the past, scientists are now generally agreed that it is about to heat up more—and faster—than ever. By the likeliest scenario, the resulting climatic changes will bedevil farming, shipping, international trade, energy policy, and military strategy. Coping with dramatic global warming will not be easy, but ignoring it would be foolish. The best bets: conserving energy and using alternative energy sources, including nuclear power.

The threat is clear. Carbon dioxide from the burning of fossil fuels like oil, coal, and gasoline is rapidly accumulating in the atmosphere. So are gases like chlorofluorocarbons (CFCs), which are far less abundant but equally devastating. CO_2, CFCs, and the other gases come almost entirely from a variety of man-made sources like vehicle exhausts and industrial solvents. Only a modest amount derives from natural sources like microbes in the soil. In the earth's atmosphere the gases act like the glass in a greenhouse, which lets in sunlight but traps heat. By absorbing rather than reflecting the infrared radiation that produces heat, they are bringing about the relentless warming of the planet known as the greenhouse effect (see box, page 104).

"My feeling is that there's no way to stop it," says Walter Roberts, president emeritus of the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, and an organizer of a year-long United States–Soviet Union conference on global warming that started meeting in May. "It may be a little bit smaller or it may be a little bit larger. But the greenhouse effect is going to come." He thinks global dependence on fossil fuels is so vast that it makes


1 Canada: Less rainfall causes crop failures in the rich farmland of Ontario.
2 Colorado River: Water levels drop, disrupting agriculture, water supplies, and power generation in eight states, including California.
3 Midwestern United States: Farming is hurt by hotter and drier summers.
4 Newfoundland and Nova Scotia: More icebergs endanger shipping.
5 Great Lakes: The busiest waterway in the world becomes ice-free 11 months of the year. But lower water levels substantially increase shipping costs and reduce generation of hydroelectric power.

REPORTER ASSOCIATE *Alicia Hills Moore*

WHAT IT WILL MEAN

serious international cooperation to reduce CO_2 emissions unlikely.

Because no one understands all the variables that alter the earth's temperature, it's not absolutely certain that the greenhouse effect will arrive as predicted or that all its dire projected consequences will actually occur (see box, page 106). Some mitigating factors exist today, and others may emerge as the effect grows. For example, while clouds high in the atmosphere tend to trap heat, low-lying clouds tend to reflect sunlight. Clouds with a high moisture content have an even greater cooling effect.

Even so, the signs are ominous. Measured by the global mean temperature, last year was the warmest year on record; the 1980s are the warmest decade in a century. A rise in the earth's temperature of at least 2° or 3° Fahrenheit seems inevitable by the mid–21st century, when the concentration of CO_2 in the atmosphere is likely to be some 60% greater than today and double the level that prevailed before the Industrial Revolution. A temperature increase of more than 8° F. is possible.

Just a 2° warming could have dramatic effects. Since that 2° is only an average figure, much larger temperature increases could occur in certain places and seasons. For in-

7 Greenland: Some of the ice cover melts, helping raise the sea level eight to 16 inches.
9 Arctic Circle: Ports in Siberia, Alaska, the Bering Sea, and the Canadian Archipelago are ice-free much of the year, enhancing commercial shipping. But American and Soviet nuclear submarines are deprived of ice cover.
8 Soviet Union: Its growing season lengthens by 40 days, but more droughts require expensive new irrigation projects.
6 Western Europe: It escapes the worst, assuming the warming Gulf Stream is not disturbed by changes brought on by the greenhouse effect.
10 China: Marginal farmland in central China may get more rain, lifting yields.
11 India and Bangladesh: Both are battered by more typhoons and flooding.
12 Equatorial Africa: The tropical rain belt moves northward, wetting parched Chad, Sudan, and Ethiopia.
13 Antarctica: Increased snow and frigid rain thicken the ice cover and counteract some of the sea level rise produced by the greenhouse effect.

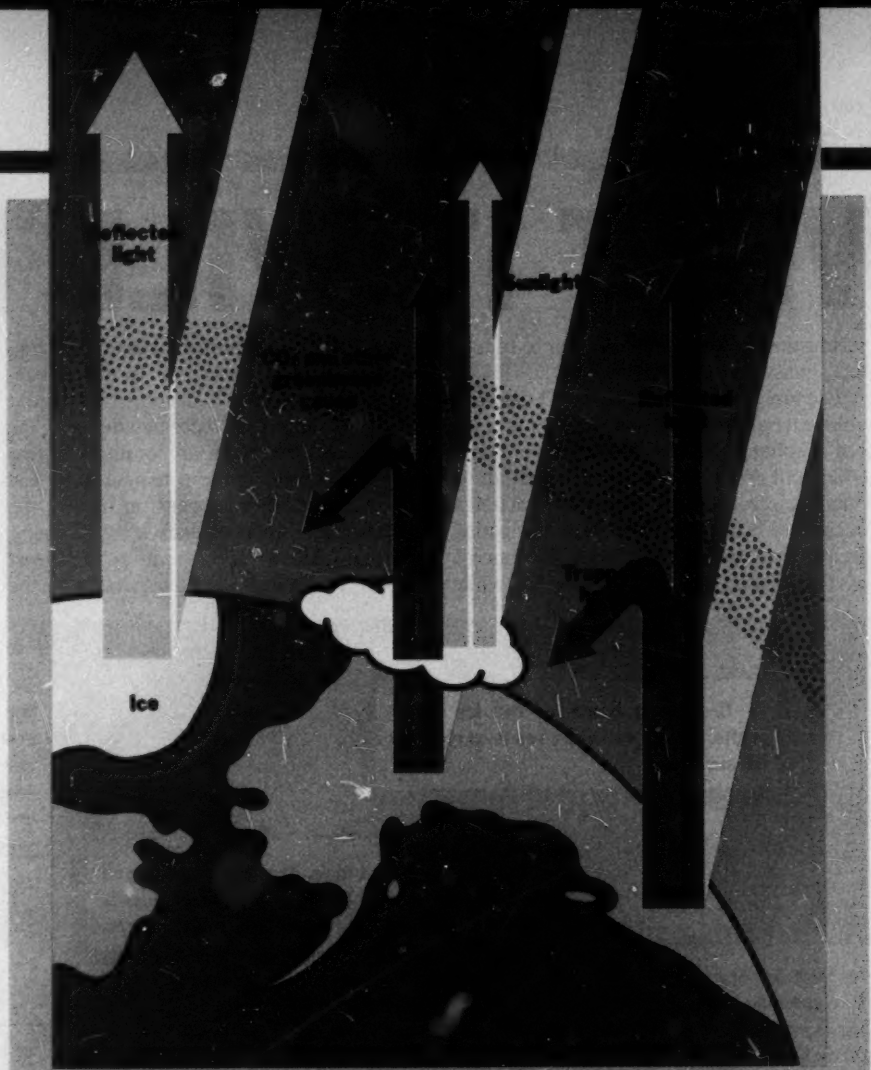
stance, one NCAR computer simulation projects a hot spot near the Bering Sea that could be nearly 30° warmer in winter than today. It took a worldwide cooling of only about 2°, perhaps due to a drop in solar radiation, to cause the Little Ice Age that wrought havoc in the 14th century. That was only a minor wobble compared with the long-term oscillations that occur over many millenniums. A seemingly small temperature shift means the difference between balmy spells and true ice ages. Civilization has developed in a narrow [illegible] of global climate, never more than 2° warmer or cooler, on average, than today's. A warming of 7° over the next 60 years or so would equal the entire rise in global temperature since the glaciers began their long retreat 18,000 years ago.

THE GREENHOUSE EFFECT will disturb the climate of the planet, changing such critical variables as rainfall, wind, cloud cover, ocean currents, and the extent of the polar icecaps. Although country-by-country consequences are far from clear, scientists are confident of the overall trends. Interiors of continents will tend to get drier and coasts wetter. Cold seasons will shorten, warm seasons lengthen. Increased evaporation will lead to drier soils over wide areas.

The ripple effects through the world economy will be enormous as shifts develop in soil conditions, crop yields, salinity of water supplies, and the availability of river water for generating hydroelectric power. Engineers will be hard put to it to anticipate future stresses on structures they build. "It may become difficult to find a site for a dam or an airport or a public transportation system or anything designed to last 30 to 40 years," says Jesse Ausubel, director of programs at the National Academy of Engineers. "What do you do when the past is no longer a guide to the future?"

Government officials and corporate executives are slowly becoming aware of the hazards of the greenhouse effect, but few are thinking of long-term strategies. Global warming was a minor item on the agenda of the Reagan-Gorbachev summit last December; the U.S. and the Soviet Union agreed to produce "a detailed study of the climate of the future."

Weyerhaeuser, the giant forest-products company in Tacoma, Washington, worries about its nearly two million acres in Oklahoma and Arkansas, where some climate scientists project a warming, drying trend.



HOW THE GREENHOUSE EFFECT WORKS

The earth grows warmer or colder mainly because of the effects of sunlight in the atmosphere. Clouds, snow, and ice reflect some sunlight back into space. But the earth absorbs much of it, converting it into infrared energy—heat. As heat rises from the earth's surface, it strikes molecules of carbon dioxide and other gases, setting them vibrating. The gas molecules reflect some of the heat back to earth, intensifying the warming effect. (For simplicity, the illustration shows the gases as a band in the atmosphere; in fact they occur throughout it.)

The more CO_2, the greater the heating. The earth's atmosphere contains substantially more CO_2 than it did before the Industrial Revolution. By analyzing cores from the ice sheets that cover Greenland and Antarctica, which enclose trapped bubbles of centuries-old atmospheric gases, scientists have concluded that in 1750 the atmosphere contained about 280 parts per million of CO_2. Today the figure is 344 ppm, nearly 25% higher.

If that trend accelerates, as most scientists now believe it will, at some point between 2030 and 2070 concentrations of CO_2 will rise to between 1.3 and 1.9 times the preindustrial level, or 367 to 531 ppm. In general, the stronger the world's economies, the more CO_2 gets spewed into the air. Scientists consider the near doubling of CO_2 more likely than the modest increase.

While CO_2 produces half the greenhouse effect, methane from such activities as growing rice and flaring natural gas wells accounts for 20% of it. Other sources: chlorofluorocarbons (CFCs) (15%); nitrous oxide, from fertilizers and microbes (10%); and ozone (5%).

ILLUSTRATIONS BY JEAN WISENBAUGH

The company is trying to breed drought resistance into the tree varieties it will plant there. British Petroleum, which has spent $11 billion on oil and gas operations in Alaska, has a particular interest in the greenhouse problem. Drilling rigs, housing, roads, and the Trans-Alaska Pipeline are all built on permafrost, which could start to thaw in a warming trend. BP has followed the scientific debate about the greenhouse effect, but at this point believes its investment is safe. The reason: BP's facilities rest on gravel pads that insulate the permafrost beneath them.

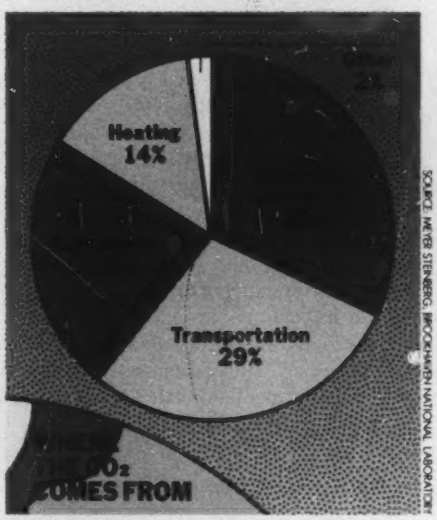
Both Alaska and Siberia have warmed up about 2.7° in just the past 20 years, according to researchers at the University of East Anglia in England. Says Michael Kelly, a climate researcher at the university and a consultant to BP: "We've now started to warn British Petroleum that 30 years out, greenhouse warming may have moved climate beyond the range of the conditions that have prevailed historically." BP is still studying the East Anglia warning.

WHAT FOLLOWS aren't hard and fast predictions of what will happen between the years 2030 and 2070, when carbon dioxide concentrations are expected to double from preindustrial levels. They are "plausible possibilities" suggested by computer models, as Howard Ferguson, assistant deputy minister of Canada's Atmospheric Environment Service, calls them.

Some of the most obvious effects will appear in agriculture. Through photosynthesis, plants make carbohydrates from CO_2 and water. As carbon dioxide concentrations increase, a plant's stomata, the pores through which gases and water vapor pass, need to open less to take in the same amount of CO_2, so the plant loses less water through evaporation. The upshot: The plant gets bigger.

If some crops grow faster, they could strip soil of nutrients more quickly, forcing farmers to buy more fertilizer. Food quality could deteriorate as CO_2 levels increase, because leaves may become richer in carbon and poorer in nitrogen. Insects feeding off plants stimulated by CO_2 would have to eat more to get their fill of nitrogen. Indeed, hungrier pests and damaging diseases might thrive on the greenhouse effect, forcing farmers to buy more pesticides as well.

The social and political consequences of the greenhouse effect are harder to assess. The Dust Bowl of the 1930s pushed millions of Midwesterners west to California; in the 1960s and 1970s, jobs and better weather pulled many millions from the Northeast to the Sunbelt. Says David Rind, a climate scientist with the Goddard Institute for Space Studies in New York City: "You may not get movements to the Southeast and Southwest anymore. It reaches 120° in Phoenix now. Will people still live there if it's 130°? 140°?" According to James Hansen of the Goddard Institute, the maximum temperature in Dallas could exceed 100° on something like 78 days a year; the current average is just 19.



The U.S. accounts for about one-fifth of the world's CO_2 emissions, and 98% of these come from burning fossil fuels.

If American agriculture is battered by such punishing summer days, and Soviet agriculture thrives owing to a longer and more temperate growing season, what would that do to the balance of power? "The United States could become a grain importer and the U.S.S.R. could become a grain exporter," says Roberts of NCAR. "At the very least, it would be a major economic, political, and social dislocation."

One of the most discussed—and feared—consequences of the greenhouse effect is a projected rise in sea level, resulting largely from thermal expansion. Like any other liquid, water increases in volume when heated. But most scientists believe the rise will be relatively gentle, on the order of eight to 16 inches, making it a problem mainly for countries with large populations near or below sea level, such as the Netherlands and Bangladesh.

Geographically, the greenhouse effect is likely to have its greatest impact in the high latitudes of the Northern Hemisphere, the broad band from 60° north—roughly the latitude of Anchorage and Stockholm—to the North Pole. A feedback effect accentuates global warming in the higher latitudes. Snow and ice reflect sunlight into space, keeping temperatures from rising. But as the globe warms, the floating Arctic ice cover starts to melt, leaving less snow and ice to reflect sunlight—enhancing the warming, which in turn melts more snow and ice. (In the Southern Hemisphere, sea ice will also melt. But the land-based Antarctic icecap is so massive—it averages two miles thick—that it would take centuries to thaw.)

IF THE WORLD as a whole warms 3° by midcentury, the higher northern latitudes might become 8° or more warmer in winter. If the global average rises 8°, winter temperatures in the higher latitudes could go up a torrid 19°. "The fabled Northwest Passage would be open," says Walt Roberts of NCAR. "You could sail from Tokyo to Europe in half the time." Maybe so, but British Petroleum and others are beginning to worry about the hazards of pack ice—large, flat masses of ice that predominate in the Arctic Ocean—and icebergs, glacier chunks like the one that sank the *Titanic*, that float off the coasts of Newfoundland and Nova Scotia. The icebergs would endanger ships and floating oil rigs.

The Arctic ice cover could also cause problems for the U.S. and Soviet defense establishments. The polar icecap of the Arctic Sea helps both Soviet and American nuclear submarines avoid detection. The effect would be more damaging to the U.S.S.R. Because American submarines are faster and can travel farther than their Soviet counterparts, they are less dependent on hiding places under the icecap.

The Soviet Union would nevertheless appear to benefit substantially from the greenhouse effect. A warming of 8° could add as many as 40 days to the growing season in the U.S.S.R. But a world with twice as much CO_2 in the atmosphere also means a continental interior that is considerably drier; the Soviet Union would have to spend tens of billions on irrigation to take advantage of the longer growing season.

How would the U.S. be affected commercially? Global warming would have strange effects on the Great Lakes, the busiest waterway in the world. Using a computer model that projects an 8° winter

WHAT MAKES THE WEATHER SO HARD TO FORECAST

How do climate scientists know the greenhouse effect will bring about the woes that they predict? They don't know to a total certainty. What they *do* know is based on half a dozen high-powered computer simulation programs, called general circulation models, in North America and Europe. Researchers feed in equations based on the laws of physics, along with assumptions about clouds, sea ice, ocean currents, soil moisture, atmospheric convection, and emission of heat from the ground.

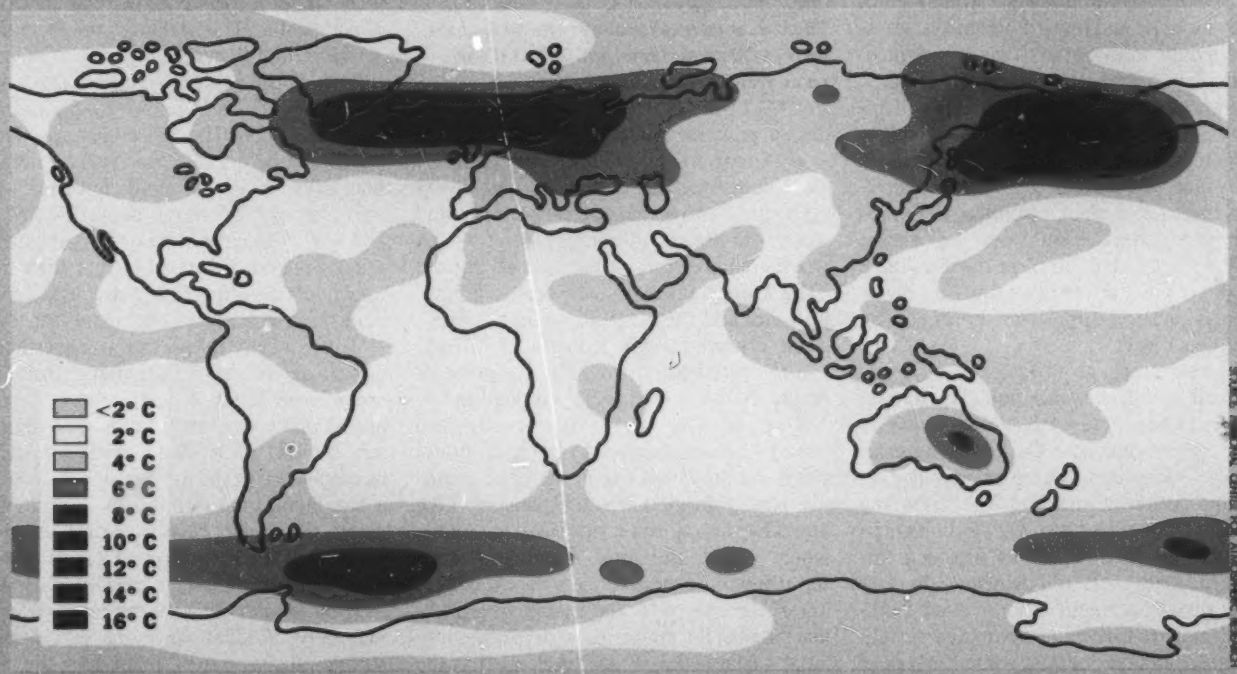
More complicated things happen in the heavens and on earth, however, than are dreamt of in the equations of scientists. Even using the best supercomputers, none of the models is so good that it can start with known weather conditions at a given point in the past and reproduce precisely what has happened since. To make the calculations manageable even by computers, most of the models suppose either that the oceans are a shallow, motionless swamp or that they don't exist at all. Despite that oversimplification, an especially sophisticated computer model at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, requires 1.5 trillion calculations to advance its predictions a single day.

One basic problem is called grid resolution. Climatologists divide the world into a grid. Most use a grid with squares the size of France. The grid defines France as a single set of numbers, failing to distinguish the cool, rainy north from the sunny, drier south. In his 1987 book *Chaos*, James Gleick, a New York *Times* reporter, imagined a world covered with a vast jungle gym of sensors spaced a foot apart and rising 35 miles to the top of the atmosphere. Each sensor measures with great precision temperature, pressure, humidity, and every other meteorological variable. An infinitely powerful computer processes all the data. This seemingly perfect monitoring system still could not predict exactly the weather next month in Atlanta.

The reason: The computer would not detect microfluctuations that took place in between the sensors. Errors multiply so quickly that within hours the reality of weather diverges from its predicted course. In effect, you can never have enough grid squares to forecast weather accurately. Tiny variations matter. The Butterfly Effect, known technically as "sensitive dependence on initial conditions," gets its name from the thought that a butterfly flapping its wings today in Nagasaki could conceivably influence storms next month in New York.

While most scientists agree that the greenhouse effect is coming, there aren't enough data yet to say with absolute conviction what its consequences will be. Certainties in science are a long time in the making. In a profession where tentative conclusions require decades' worth of data, one swallow does not make a summer. As recently as the 1970s some climatologists were worrying about global *cooling*, because world temperatures had peaked in the 1940s and then declined into the 1970s. Air pollutants such as volcanic and man-made dust may have blocked enough sunlight to lower global temperatures.

This computer model shows possible rises in winter temperatures, in Celsius, if CO_2 in the air doubles from the 18th-century level.



warming, the Atmospheric Environment Service says the Great Lakes could be ice-free 11 months of the year, vs. 8.5 months today. That's the good news. The bad news is that the region will also be drier, so companies shipping such major cargoes as iron ore, grain, coal, and limestone will see costs rise 30% or so because lower water levels will mean that deep-draft freighters can no longer navigate the lock systems.

PERHAPS the biggest agricultural impact on the U.S. would be in the Midwest, where climate researchers predict a warming, drying trend. Staggering wheat crop losses deepened the Great Depression and prompted the biggest population migration in American history. When temperatures rise as little as 1.8° and precipitation drops 10%, Midwestern crops will suffer. Paul Waggoner, director of the Connecticut Agricultural Experiment Station in New Haven, sees a 2% to 5% cut in the yield of commercially desirable winter wheat.

Western Europe might escape the nastier consequences of global warming because its relatively small landmass is close to the sea and will not undergo the same degree of continental drying as the U.S., Canada, and the Soviet Union. What will happen to European temperatures is being debated. Most scientists think the Gulf Stream, flowing thousands of miles from the Caribbean, should continue to keep Western Europe from freezing to the consistency of Newfoundland, which is at the same latitude. But Wallace Broecker of Columbia University's Lamont-Doherty Geological Observatory in Palisades, New York, warns that the greenhouse effect could disturb the global circulation of the oceans in ways that cannot be predicted. Like a teakettle that doesn't boil the moment it's switched on, the earth's oceans, which range up to seven miles deep, take time to warm up. It could take 20 to 60 years before the oceans show the full effect of global warming.

Research on the effects of global warming in countries of the Third World and the Southern Hemisphere is sketchier. Africa may benefit, at least in rainfall. The rain belt across the equator would move northward, according to research about to be published by Syukuro Manabe, a climate modeler at Princeton's Geophysical Fluid Dynamics Laboratory. That's good news for the parched nations of the Sahel, including Chad, Sudan, and Ethiopia, which have suffered this century's deadliest droughts. Marginal farmland in central China may get more rainfall, increasing crop yields. India and especially Bangladesh, a third of which is only 20 feet above sea level, on average, would be battered by more storms and flooding.

"When climate changes," a United Nations Environment Program (UNEP) report bluntly declared last year, "society suffers." So what should we do?

Clearly there are things we can't do. We can't scrub carbon dioxide out of industrial emissions the way we can pollutants like sulfur dioxide. So-called chemically alkaline absorbent systems that soak up CO_2 emissions add as much as 80% to the cost of producing electricity. The most efficient CO_2 scrubbers are trees. Like other plants they absorb CO_2, using it to make food and build wood. But trees are being felled around the world at a clip of 50 acres a minute, mostly in Brazil, West Africa, and Indonesia, according to UNEP. Reducing deforestation would help, but reforestation, proposed occasionally, isn't a practical answer. The Oak Ridge National Laboratory in Tennessee estimates that to stop the greenhouse effect cold would take 1.7 billion acres of sycamore trees, which are especially good at soaking up CO_2. That's an area roughly the size of Australia.

In a sense, getting up in the morning adds to the greenhouse effect. Everyone contributes. If everyone is to blame, no one is to blame.

Changing the mix of fossil fuels can help. Natural gas produces half the CO_2 of coal and about two-thirds that of oil for the same amount of energy. While it's unlikely to happen, shifting completely to natural gas from coal or petroleum could extend by 20 to 30 years the time it takes for atmospheric CO_2 to double from preindustrial levels.

Some help should come from a 1987 treaty curbing production of chlorofluorocarbons. Released into the atmosphere, these synthetic chemicals, used in industrial solvents and refrigerants, eat away at the atmospheric ozone layer that protects people from dangerous solar radiation, which can cause skin cancer and cataracts. If the signatories comply, CFC production would be limited to 1986 levels beginning next year and gradually drop 50% by 1999.

Unfortunately, the CFC agreement is not a model for curtailing carbon dioxide. In that case a single industry was the source of the problem; there was someone to blame. Once persuaded by strong scientific evidence, the chemical industry agreed to institute production curbs. By contrast, no one controls the production of carbon dioxide. It is a result of everyday processes of life. In a sense, getting up in the morning adds to the greenhouse effect. Turning on the bathroom light uses electricity generated by fossil fuels; driving to work burns gasoline; even the building you work in may have added to the problem because making concrete gives off CO_2. Everyone contributes to the greenhouse effect. If everyone is to blame, no one is to blame.

Energy conservation would reduce carbon dioxide emissions at the source, but would be tough to enforce. Most alternative energy sources seem impractical, for the moment. Wind, geothermal, and solar energy have so far been casualties of low oil prices. So have synfuels, which have the added disadvantage of producing as much carbon dioxide as fossil fuels. Nuclear energy, despite well-deserved public concern about its safety, may deserve a second look because it produces no carbon dioxide.

ALL THESE strategies seek to buy time. Obviously it is better to adjust to the greenhouse effect over 200 years rather than 50. But an all-out international effort to reduce CO_2 emissions seems sure to hit two major snags. Countries that stand to benefit from global warming aren't likely to bring much enthusiasm to averting it. And those that stand to lose have trouble viewing this distant, somewhat speculative threat with the urgency required to call forth expensive and disruptive countermeasures.

If nations don't take action, Mick Kelly of the University of East Anglia suggests what businesses might do. "The winners from global warming," he says, "are going to be those people who think ahead of time and plan. The losers are going to be those who respond only when the crisis arrives, on the spur of the moment." For those who want to come out winners, now is not too soon to start thinking. F